# NASA/TM-2000-209891, Vol. 154



# Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Shelaine Curd, Editors

# Volume 154 BOREAS TE-9 NSA Canopy Biochemistry

H. Margolis, M. Charest, and M. Sy

National Aeronautics and Space Administration

**Goddard Space Flight Center** Greenbelt, Maryland 20771

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Hank Margolis, Martin Charest, and Mikailou Sy Université Laval, Sainte-Foy, Quebec, Canada

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# **BOREAS TE-9 NSA Canopy Biochemistry**

Hank Margolis, Martin Charest, Mikailou Sy

# Summary

The BOREAS TE-9 team collected several data sets related to chemical and photosynthetic properties of leaves. This data set contains canopy biochemistry data collected in 1994 in the NSA at the YJP, OJP, OBS, UBS, and OA sites, including biochemistry lignin, nitrogen, cellulose, starch, and fiber concentrations. These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. The data are available in tabular ASCII files.

#### **Table of Contents**

- 1) Data Set Overview
- 2) Investigator(s)
- 3) Theory of Measurements
- 4) Equipment
- 5) Data Acquisition Methods
- 6) Observations
- 7) Data Description
- 8) Data Organization
- 9) Data Manipulations
- 10) Errors
- 11) Notes
- 12) Application of the Data Set
- 13) Future Modifications and Plans
- 14) Software
- 15) Data Access
- 16) Output Products and Availability
- 17) References
- 18) Glossary of Terms
- 19) List of Acronyms
- 20) Document Information

#### 1. Data Set Overview

#### 1.1 Data Set Identification

BOREAS TE-09 NSA Canopy Biochemistry

#### 1.2 Data Set Introduction

These data describe the canopy biochemistry (lignin, nitrogen, cellulose, starch, fiber) at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) Young Jack Pine (YJP), Old Jack Pine (OJP), Old Black Spruce (OBS), Upland Black Spruce (UBS), and Old Aspen (OA) sites.

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing.

#### 1.3 Objective/Purpose

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. Canopy biochemistry (lignin, nitrogen, cellulose, starch, fiber) can be related to a number of ecosystem processes, such as litter decomposition, nutrient cycling rates, soil CO<sub>2</sub> fluxes, carbon allocation between below ground and above ground components, and photosynthetic capacity. There is some evidence suggesting that several aspects of canopy biochemistry can be estimated using high-resolution reflectance data in the mid-infrared. While several biochemical components can be accurately measured in the laboratory with ground plant material, making reliable estimates in real forests is difficult because the structure of shoots, branches, and trees influences the reflectance spectra.

#### 1.4 Summary of Parameters

Sampling period, site identification, sample identification, fiber concentration (%), cellulose concentration (%), lignin concentration (%), total soluble sugars (%), nitrogen concentration (%), and starch concentration (%).

#### 1.5 Discussion

At the NSA (Thompson, Manitoba), foliage from the upper third of the canopies of the YJP, OJP, OBS, and UBS stands was sampled five times during 1994 in conjunction with each field campaign (Focused Field Campaign Winter (FFC-W), FFC-Thaw (FFC-T), Intensive Field Campaign (IFC)-1, IFC-2, and IFC-3), while samples from OA were taken only during IFCs. Samples were taken either on the day of or on the day following the Airborne Visible and Infrared Imagining Spectrometer (AVIRIS) missions in the NSA. Five samples were taken from five different dominant trees at each site at each date. Trees sampled were black spruce (Picea mariana), jack pine (Pinus banksiana), and aspen (Populus tremuloides). Samples were lyophilisated and ground (Tecator Cyclotec 1093 sample mill) to pass through a 0.40-mm mesh screen. For each biochemical component, analyses were conducted on two random subsamples that were equivalent to 100 mg dry weight for total soluble sugars or starch concentration; 1 g for fiber, cellulose, or lignin concentrations; and 500 mg for nitrogen concentration. Data given in TABLE1 were averaged for the two subsamples.

#### 1.6 Related Data Sets

BOREAS TE-09 NSA Photosynthetic Capacity and Foliage Nitrogen Data BOREAS TE-09 PAR and Leaf Nitrogen Data for NSA Species BOREAS TE-09 In Situ Diurnal Gas Exchange of NSA Boreal Forest Stands

# 2. Investigator(s)

#### 2.1 Investigator(s) Name and Title

Hank Margolis, Ph.D. Universite Laval Faculte de foresterie et de geomatique

#### 2.2 Title of Investigation

Relationship Between Measures of Absorbed and Reflected Radiation and the Photosynthetic Capacity of Boreal Forest Canopies and Understories

#### 2.3 Contact Information

#### Contact 1:

Martin Charest Universite Laval Faculte de foresterie et de geomatique Pavillon Abitibi-Price Sainte-Foy, Quebec Canada G1K 7P4 (418) 656-2131, ext. 4063 Charest@vm1.ulaval.ca

#### Contact 2:

Mikailou Sy Universite Laval Faculte de foresterie et de geomatique Pavillon Abitibi-Price Sainte-Foy, Quebec Canada G1K 7P4

#### Contact 3:

Hank Margolis, Ph.D. Universite Laval Faculte de foresterie et de geomatique Pavillon Abitibi-Price Sainte-Foy, Quebec Canada G1K 7P4 (418) 656-7120 margolha@vm1.ulaval.ca

#### Contact 4:

Shelaine Curd Raytheon ITSS Code 923 NASA GSFC Greenbelt, MD 20771 (301) 286-2447 (301) 286-0239 (fax) shelaine.curd@gsfc.nasa.gov

# 3. Theory of Measurements

For total soluble sugars and starch concentrations, each subsample was extracted in a 15-ml aliquot of methanol-chloroform-water solvent (M-C-W: 12-5-3). Extracts were centrifuged three times for 5 minutes each time at 3,500 rpm. Two 75-ml aliquots were used to quantify soluble sugars (Dubois et al., 1956), and another group of two 75-ml aliquots was used for starch (Boehringer Mannheim Company, 1993). Spectrophotometric measurements were made using a Spectronic 20 (Bausch and Lomb). Transmittance readings first were made using glass cells and were then converted to corresponding absorbencies.

Fiber, lignin, and cellulose analyses were conducted following material extraction in a mixture of H<sub>2</sub>SO<sub>4</sub> 0.5 M and cetyltrimethylammonium bromide (Ryan et al., 1990). Fiber concentration was analyzed from these first extracts while lignin and cellulose were conducted on insoluble residues (Ryan et al., 1990). A second extraction in 72% H<sub>2</sub>SO<sub>4</sub> for 3 hours at 20-23 °C removed the cellulose

concentration (Ryan et al., 1990). Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration (Ryan et al., 1990).

Nitrogen concentration analysis was conducted using the micro-Kjeldahl method (Parkinson and Allen, 1975). The sample distillation was conducted using a Kjeltec 1030 autoanalyzer, which is a single unit for fast and automatic distillation, titration, and calculation using the Kjeldahl method. Results from this distillator model are presented on a digital display or printed.

# 4. Equipment

#### 4.1 Sensor/Instrument Description

Shotgun, cooler with icebags, plastic bags, pruner, automatic dispenser, glass test tubes, Eppendorf pipet, high-precision balance grinding machine, centrifuge, distillator, spectrophotometer, glass cells, chemical products, lysophilisator.

#### 4.1.1 Collection Environment

**Sites:** Samples were collected from five sites at the NSA in Thompson, Manitoba. The sites are described in Appendix I and can be identified in Figure 5.1.5a of the BOREAS Experiment Plan, Version 3.0.

NSA-YJP: T8S9T NSA-OJP: T7Q8T NSA-OBS: T3R8T NSA-BS: T6R5S NSA-OA: T2Q6A

**Sampling:** Sampling dates, except those in the winter and thaw periods, correspond with either the day of or the day following the AVIRIS missions in the NSA. For each site, branches were taken from the upper third of the canopy of five dominant trees in a representative location using a shotgun. Branches were kept in labeled plastic bags, stored in a cooler containing icebags, and transported to the laboratory in Thompson. From each bag, an appropriate amount of foliage was lyophilisated and ground. Two equivalent subsamples were then taken and extracted for each biochemical component. Analyses were conducted on those extracts.

**Extractions:** Automatic dispensers were used to deliver the 15-ml aliquots of methanol-chloroform-water solvent (M-C-W: 12-5-3) in glass test tubes containing ground material for soluble sugars and starch analysis.

Raw fiber concentration is strongly correlated to the proximate carbon fraction (Ryan et al., 1990) and is used in entomology to estimate the non-nutritive component of foliage. It was determined from a mixture of H<sub>2</sub>SO<sub>4</sub> 0.5 M and cetyltrimethyl-ammonium extracts. Residues of this first extraction were extracted in 72% H<sub>2</sub>SO<sub>4</sub> for 3 hours at 20-23 °C to remove cellulose concentration. Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration. For nitrogen analysis, samples were digested using a solution mixing 350 ml of H<sub>2</sub>O<sub>2</sub>, 0.42 g Se powder, and 14 g Li<sub>2</sub>SO<sub>4</sub>. H<sub>2</sub>O in a flat-bottomed, boiling flask and carefully adding 420 ml H<sub>2</sub>SO<sub>4</sub> while swirling and cooling the mixture was stored at 1 °C.

**Quantities estimated:** Components were calculated according to respective references and were expressed in percentage of foliage material dry weight basis.

#### 4.1.2 Source/Platform

One or two persons collected branches at all sites, put them in labeled plastic bags in a cooler containing icebags, and transported them to laboratory. Foliage was then sampled, lyophilisated, and ground. Subsamples were taken for extractions and analyses.

#### 4.1.3 Source/Platform Mission Objectives

The mission was undertaken to establish the relationship between biochemical patterns and high-resolution mid-infrared reflectance data taken with AVIRIS on the National Aeronautics and Space Administration (NASA) ER-2 aircraft.

#### 4.1.4 Key Variables

Foliar concentrations in fiber (%), cellulose (%), lignin (%), total soluble sugars (%), nitrogen (%), and starch (%).

#### 4.1.5 Principles of Operation

Not applicable.

#### 4.1.6 Sensor/Instrument Measurement Geometry

Samples were harvested from the upper third of the canopy of five dominant trees for all sites at all sampling dates.

#### 4.1.7 Manufacturer of Sensor/Instrument

Grinding machine Tecator Cyclotec 1093 sample mill Tecator, Inc. P.O. Box 405 Herndon, VA 22070 USA (703) 435-3300

Weighing balance Mettler-Toledo AG, Type AB104 IM Langacher, CH-8606 Greifensee Switzerland (01) 944 22 11 Telex: 82 61 50

Chemical Products Sigma Chemical Company P.O. Box 14508 St. Louis, MO 63178-9916 USA 1 (800) 325-3010

Centrifuge IEC Model HN-SII Centrifuge 300 Second Avenue Needham Heights, MA 02194 USA

Spectrophotometer Spectronic 20 Bausch and Lomb Glass cells Hellma Fisher Scientific, 8505 Devonshire Rd., Montreal (Quebec) Canada H4P 2 L4 Starch test kit Boehringer Mannheim, UV-method, Cat. No. 207748 Sigma Chemical Company P.O. Box 14508 St. Louis, MO 63178-9916 USA 1 (800) 325-3010

Distillator Kjeltec auto1030 analyzer Tecator, Inc. P.O. Box 405 Herndon, VA 22070 USA (703) 435-3300

Dispenser Compet, 5 ml bottle top dispenser Nichiryo Co. LTD. Tokyo, Japan

#### 4.2 Calibration

#### 4.2.1 Specifications

The weighing balance was accurate to within 0.0001 g. The automatic dispenser was accurate to within 1%. The spectrophotometer was accurate to within 0.001 absorbance unit.

#### **4.2.1.1** Tolerance

Not applicable.

# 4.2.2 Frequency of Calibration

The control level on the spectrophotometer was verified (0 absorbance unit) after each group of five samples.

#### 4.2.3 Other Calibration Information

Not available.

# 5. Data Acquisition Methods

**Sites:** Samples were collected from five NSA sites in Thompson, Manitoba. The sites are described in Appendix I and can be identified in Figure 5.1.5a of the BOREAS Experiment Plan (Version 3.0).

NSA-YJP: T8S9T NSA-OJP: T7Q8T NSA-OBS: T3R8T NSA-BS: T6R5S NSA-OA: T2Q6A

**Sampling:** Sampling dates, except those in the winter and thaw periods, correspond with either the day of or the day following the AVIRIS missions in the NSA. For each site, branches were taken from the upper third of the canopy of five dominant trees in a representative location using a shotgun. Branches were kept in labeled plastic bags, stored in a cooler containing icebags, and transported to the laboratory in Thompson. From each bag, an appropriate amount of foliage was lyophilisated and ground. Two equivalent subsamples were then taken and extracted for each biochemical component. Analyses were conducted on those extracts.

**Extractions:** Automatic dispensers were used to deliver the 15-ml aliquots of methanol-chloroform-water solvent (M-C-W: 12-5-3) in glass test tubes containing ground material for soluble sugars and starch analysis.

Raw fiber concentration is strongly correlated to the proximate carbon fraction (Ryan et al., 1990) and is used in entomology to estimate the non-nutritive component of foliage. It was determined from a mixture of  $H_2SO_4$  0.5 M and cetyltrimethyl-ammonium extracts. Residues of this first extraction were extracted in 72%  $H_2SO_4$  for 3 hours at 20-23 °C to remove cellulose concentration. Residues were then ashed at 450 °C for 8 hours to obtain the ash-free lignin concentration. For nitrogen analysis, samples were digested using a solution of 350 ml of  $H_2O_2$ , 0.42 g of Se powder, and 14 g of  $Li_2SO_4$ .  $H_2O$  in a flat-bottomed 1-liter boiling flask and carefully adding 420 ml  $H_2SO_4$  while swirling and cooling the mixture, which was stored at 1 °C.

**Quantities estimated:** Components were calculated according to respective references and were expressed in percentage of foliage material dry weight basis.

#### 6. Observations

#### 6.1 Data Notes

None.

#### **6.2 Field Notes**

None.

# 7. Data Description

## 7.1 Spatial Characteristics

# 7.1.1 Spatial Coverage

The North American Datum of 1983 (NAD83) coordinates for the sites are:

- NSA-YJP flux tower site: Lat/Long: 55.89575°N, 98.28706°W; UTM Zone 14, N: 6194706.9, E: 544583.9
- NSA-OJP flux tower site: Lat/Long: 55.842°N, 98.62396°W; UTM Zone 14, N: 6198176.3, E: 523496.2
- NSA-OA canopy access tower site (auxilliary site number T2Q6A, BOREAS Experiment Plan, Version 3.0): Lat/Long: 55.88691°N, 98.67479°W; UTM Zone 14, N 6193540.7, E 520342
- NSA-OBS flux tower site: Lat/Long: 55.88007°N, 98.48139°W; UTM Zone 14, N:6192853.4, E: 532444.5
- NSA-UBS canopy access tower site (auxilliary site number T6R5S, BOREAS Experiment Plan, Version 3.0): Lat/Long: 55.90802°N, 98.51865°W; UTM Zone 14, N 6195947 E 530092

#### 7.1.2 Spatial Coverage Map

Not applicable.

#### 7.1.3 Spatial Resolution

These data represent point source measurements that may be generally representative.

#### 7.1.4 Projection

Not applicable.

#### 7.1.5 Grid Description

Not applicable.

#### 7.2 Temporal Characteristics

#### 7.2.1 Temporal Coverage

The overall time period of sample acquisition was from 01-Feb-1994 through 18-Sep-1994.

### 7.2.2 Temporal Coverage Map

Samples were collected on the following dates:

IFC	Sites (NSA) and Dates
FFC-W	OJP, OBS, and YJP on 17-Feb-1994 TE-BS on 18-Feb-1994
FFC-T	OJP, OBS, and YJP on 28-Apr-1994 TE-BS on 29-Apr-1994
IFC-1	OA, OJP, and YJP on 08-Jun-1994 OBS and BS on 09-Jun-1994
IFC-2	OASP, OJP, and BS on 04-Aug-1994 OBS and YJP on 05-Aug-1994
IFC-3	OBS on 15-Sep-1994 OASP, YJP, OJP, and BS on 16-Sep-1994

#### 7.2.3 Temporal Resolution

For each sampling date, branches were collected at 6:00 a.m. (local time) for OBS, at 8:00 a.m. for YJP, and between 3:00 p.m. and 6:00 p.m. for the UBS, OJP, and OA sites.

#### 7.3 Data Characteristics

#### 7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

#### BIOCHEM\_AVG\_DATA

Column Name

\_\_\_\_\_

SITE\_NAME

SUB\_SITE

START\_DATE

END\_DATE

SPECIES

MEAN\_FIBER\_CONTENT

STD\_ERR\_FIBER\_CONTENT

MEAN\_CELLULOSE\_CONTENT

STD\_ERR\_CELLULOSE\_CONTENT

MEAN\_LIGNIN\_CONTENT

STD\_ERR\_LIGNIN\_CONTENT

MEAN\_TS\_SUGAR\_CONTENT

STD\_ERR\_TS\_SUGAR\_CONTENT

MEAN\_NITROGEN\_CONTENT

STD\_ERR\_NITROGEN\_CONTENT
MEAN\_STARCH\_CONTENT
STD\_ERR\_STARCH\_CONTENT
CRTFCN\_CODE
REVISION\_DATE

#### BIOCHEM\_POINT\_DATA

Column Name

-----

SITE\_NAME
SUB\_SITE
START\_DATE
END\_DATE
END\_DATE
SPECIES
BAG\_SAMPLE\_ID
FIBER\_CONTENT
CELLULOSE\_CONTENT
LIGNIN\_CONTENT
TS\_SUGAR\_CONTENT
NITROGEN\_CONTENT
STARCH\_CONTENT
CRTFCN\_CODE
REVISION\_DATE

# 7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

#### BIOCHEM\_AVG\_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREA S, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
START_DATE	The date on which the collection of the reference data commenced.
END_DATE	The date on which the collection of the referenced data was terminated.
SPECIES	Botanical (Latin) name of the species (Genus species).
MEAN_FIBER_CONTENT	The mean fiber content of the sample.
STD_ERR_FIBER_CONTENT	Standard error for the fiber content of the sample.
MEAN_CELLULOSE_CONTENT	The mean cellulose content of the sample.
STD_ERR_CELLULOSE_CONTENT	Standard error for the cellulose content of the

sample.

MEAN\_LIGNIN\_CONTENT The mean lignin content of the sample.

STD ERR LIGNIN CONTENT Standard error for the lignin content of the

sample.

sample.

STD\_ERR\_TS\_SUGAR\_CONTENT Standard error for the total soluble sugars

content in the sample.

MEAN\_NITROGEN\_CONTENT The mean nitrogen content of the sample.

STD\_ERR\_NITROGEN\_CONTENT Standard error for the nitrogen content of the

sample.

MEAN\_STARCH\_CONTENT The mean starch content of the sample.

STD\_ERR\_STARCH\_CONTENT Standard error for the starch content of the

sample.

CRTFCN\_CODE The BOREAS certification level of the data.

Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI

but questionable).

REVISION\_DATE The most recent date when the information in the

referenced data base table record was revised.

#### BIOCHEM\_POINT\_DATA

Column Name Description

SITE NAME The identifier assigned to the site by BOREAS,

The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG,

TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with

site type.

SUB\_SITE The identifier assigned to the sub-site by

 ${\tt BOREAS}\,,$  in the format GGGGG-IIIII, where GGGGG is

the group associated with the sub-site

instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to

an instrument.

START\_DATE The date on which the collection of the reference

data commenced.

END\_DATE The date on which the collection of the

referenced data was terminated.

SPECIES Botanical (Latin) name of the species (Genus

species).

BAG\_SAMPLE\_ID Branches collected from each tree were stored in

two bags identified as 1, 2, or A, B. Example:
1.1 = sample 1 from bag 1-- 5.A sample 5 from

bag A.

FIBER\_CONTENT The fiber content of the sample.

CELLULOSE\_CONTENT The cellulose content of the sample.

LIGNIN\_CONTENT The lignin content of the sample.

TS\_SUGAR\_CONTENT The total soluble sugars content of the sample.

NITROGEN\_CONTENT The nitrogen content of the sample. STARCH\_CONTENT The starch content of the sample.

CRTFCN\_CODE The BOREAS certification level of the data.

Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI

but questionable).

REVISION\_DATE The most recent date when the information in the referenced data base table record was revised.

#### 7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

#### BIOCHEM\_AVG\_DATA

Column Name	Units
CTER NAME	[1
SITE_NAME	[none]
SUB_SITE	[none]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SPECIES	[none]
MEAN_FIBER_CONTENT	[percent]
STD_ERR_FIBER_CONTENT	[percent]
MEAN_CELLULOSE_CONTENT	[percent]
STD_ERR_CELLULOSE_CONTENT	[percent]
MEAN_LIGNIN_CONTENT	[percent]
STD_ERR_LIGNIN_CONTENT	[percent]
MEAN_TS_SUGAR_CONTENT	[percent]
STD_ERR_TS_SUGAR_CONTENT	[percent]
MEAN_NITROGEN_CONTENT	[percent]
STD_ERR_NITROGEN_CONTENT	[percent]
MEAN_STARCH_CONTENT	[percent]
STD_ERR_STARCH_CONTENT	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

#### BIOCHEM\_POINT\_DATA

Column Name	Units	
SITE_NAME	[none]	
SUB_SITE	[none]	
START_DATE	[DD-MON-YY]	
END_DATE	[DD-MON-YY]	
SPECIES	[none]	
DAG CAMPIE ID	[none]	

[none] BAG\_SAMPLE\_ID FIBER\_CONTENT [percent] CELLULOSE\_CONTENT [percent] LIGNIN\_CONTENT [percent] TS\_SUGAR\_CONTENT [percent] NITROGEN\_CONTENT [percent] STARCH\_CONTENT [percent] CRTFCN\_CODE [none] REVISION\_DATE [DD-MON-YY]

#### 7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

#### BIOCHEM\_AVG\_DATA

Column Name	Data Source
SITE_NAME	BORIS Designation
SUB_SITE	BORIS Designation
START_DATE	BORIS Designation
END_DATE	BORIS Designation
SPECIES	Human Observer
MEAN_FIBER_CONTENT	Laboratory Equipment
STD_ERR_FIBER_CONTENT	Laboratory Equipment
MEAN_CELLULOSE_CONTENT	Laboratory Equipment
STD_ERR_CELLULOSE_CONTENT	Laboratory Equipment
MEAN_LIGNIN_CONTENT	Laboratory Equipment
STD_ERR_LIGNIN_CONTENT	Laboratory Equipment
MEAN_TS_SUGAR_CONTENT	Laboratory Equipment
STD_ERR_TS_SUGAR_CONTENT	Laboratory Equipment
MEAN_NITROGEN_CONTENT	Laboratory Equipment
STD_ERR_NITROGEN_CONTENT	Laboratory Equipment
MEAN_STARCH_CONTENT	Laboratory Equipment
STD_ERR_STARCH_CONTENT	Laboratory Equipment
CRTFCN_CODE	BORIS Designation
REVISION_DATE	BORIS Designation

#### BIOCHEM\_POINT\_DATA

SITE\_NAME

SUB SITE

Column Name	Data Source

BORIS Designation

BORIS Designation BORIS Designation BORIS Designation START\_DATE END DATE Human Observer
Human Observer
Laboratory Equipment
Laboratory Equipment
Laboratory Equipment SPECIES BAG\_SAMPLE\_ID FIBER CONTENT CELLULOSE\_CONTENT LIGNIN CONTENT Laboratory Equipment
Laboratory Equipment
Laboratory Equipment
BORIS Designation TS\_SUGAR\_CONTENT NITROGEN\_CONTENT STARCH\_CONTENT CRTFCN CODE REVISION\_DATE BORIS Designation

**7.3.5 Data Range**The following table gives information about the parameter values found in the data files on the CD-ROM.

BIOCHEM	AVG	DA	TΑ
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Column Name	Minimum Data Value	Maximum Data Value	Data	Data	Below Detect Limit	Not Cllctd
SITE_NAME	NSA-9BS-9TETR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE09-BCA01	9TE09-BCA01	None	None	None	None
START_DATE	01-FEB-94	30-AUG-94	None	None	None	None
END_DATE	16-FEB-94	19-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
MEAN_FIBER_CONTENT	13.69	37.38	None	None	None	None
STD_ERR_FIBER_ CONTENT	.285	2.538	None	None	None	None
MEAN_CELLULOSE_ CONTENT	11.52	21.36	None	None	None	None
STD_ERR_CELLULOSE_ CONTENT	.208	3.531	None	None	None	None
MEAN_LIGNIN_CONTENT	11.86	21.74	None	None	None	None
STD_ERR_LIGNIN_		3.028	None	None	None	None
CONTENT						
MEAN_TS_SUGAR_ CONTENT	6.906	14.292	None	None	None	None
STD_ERR_TS_SUGAR_ CONTENT	.22	1.581	None	None	None	None
MEAN_NITROGEN_ CONTENT	.586	2.092	None	None	None	None
STD_ERR_NITROGEN_ CONTENT	.014	.333	None	None	None	None
MEAN_STARCH_CONTENT STD_ERR_STARCH_ CONTENT		16.211 2.497	None None	None None	None None	None None
CONTENT CRTFCN_CODE REVISION_DATE		CPI 18-SEP-96		None	None None	None

BIOCHEM\_POINT\_DATA

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	NSA-9BS-9TETR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE09-BCP01	9TE09-BCP01	None	None	None	None
START_DATE	01-FEB-94	30-AUG-94	None	None	None	None
END_DATE	16-FEB-94	19-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
BAG_SAMPLE_ID	1.1	5.A	None	None	None	None
FIBER_CONTENT	12.26	38.5	-999	None	None	None
CELLULOSE_CONTENT	8.837	28.135	-999	None	None	None
LIGNIN_CONTENT	5.416	28.035	-999	None	None	None
TS_SUGAR_CONTENT	5.808	16.558	-999	None	None	None

NITROGEN_CONTENT STARCH_CONTENT CRTFCN_CODE REVISION_DATE	.457 .501 CPI 18-SEP-96	2.649 20.28 CPI 18-SEP-96	-999 -999 None None	None None None	None None None	None None None None
Minimum Data Value Maximum Data Value Missng Data Value	The maximum	value found in	the colur	mn.	s is used	d to

Unrel Data Value

parameter value, but the attempt was unsuccessful. -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.

indicate that an attempt was made to determine the

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Cllctd

-- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value. N/A -- Indicates that the value is not applicable to the respective column. None -- Indicates that no values of that sort were found in the column.

#### 7.4 Sample Data Record

The following is a sample of the first few records from the data table on the CD-ROM:

#### BIOCHEM\_AVG\_DATA

SITE\_NAME, SUB\_SITE, START\_DATE, END\_DATE, SPECIES, MEAN\_FIBER\_CONTENT, STD\_ERR\_FIBER\_CONTENT, MEAN\_CELLULOSE\_CONTENT, STD\_ERR\_CELLULOSE\_CONTENT, MEAN\_LIGNIN\_CONTENT,STD\_ERR\_LIGNIN\_CONTENT,MEAN\_TS\_SUGAR\_CONTENT, STD\_ERR\_TS\_SUGAR\_CONTENT, MEAN\_NITROGEN\_CONTENT, STD\_ERR\_NITROGEN\_CONTENT, MEAN\_STARCH\_CONTENT,STD\_ERR\_STARCH\_CONTENT,CRTFCN\_CODE,REVISION\_DATE 'NSA-90A-9TETR','9TE09-BCA01',24-MAY-94,16-JUN-94,'Populus tremuloides',13.69, .508,20.43,3.531,21.74,2.507,13.305,.617,1.81,.333,4.279,.501,'CPI',18-SEP-96 'NSA-90A-9TETR','9TE09-BCA01',19-JUL-94,08-AUG-94,'Populus tremuloides',26.22, 1.156,11.52,.34,14.0,.795,11.28,.341,2.092,.066,5.932,.41,'CPI',18-SEP-96

#### BIOCHEM\_POINT\_DATA

SITE\_NAME, SUB\_SITE, START\_DATE, END\_DATE, SPECIES, BAG\_SAMPLE\_ID, FIBER\_CONTENT, CELLULOSE\_CONTENT, LIGNIN\_CONTENT, TS\_SUGAR\_CONTENT, NITROGEN\_CONTENT, STARCH\_CONTENT, CRTFCN\_CODE, REVISION\_DATE 'NSA-90A-9TETR','9TE09-BCP01',24-MAY-94,16-JUN-94,'Populus tremuloides','4.1', 13.976,20.02,19.86,12.417,1.748,2.615,'CPI',18-SEP-96 'NSA-90A-9TETR','9TE09-BCP01',24-MAY-94,16-JUN-94,'Populus tremuloides','3.1', 12.26,28.135,28.035,12.589,1.181,3.877,'CPI',18-SEP-96

# 8. Data Organization

#### 8.1 Data Granularity

The smallest unit of orderable data is data collected on one day at one site.

#### 8.2 Data Format(s)

In BIOCHEM\_AVG\_DATA, data are presented for each sample (i.e., for each tree) and represent the average of two subsamples. In BIOCHEM\_POINT\_DATA, the subsequent averaged contents and corresponding standard errors are given on the basis of both site and sampling date.

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

# 9. Data Manipulations

#### 9.1 Formulae

None.

#### 9.1.1 Derivation Techniques and Algorithms

None.

## 9.2 Data Processing Sequence

None.

#### 9.2.1 Processing Steps

Data were recorded automatically by a computer and also printed on a printer. Subsequent calculations of different parameters were performed using MS Excel for Windows 5.0.

BOREAS Information System (BORIS) staff processed the data by:

- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the TE-09 team to document the data set.
- Extracting the standardized data into logical files.

#### 9.2.2 Processing Changes

None.

#### 9.3 Calculations

All variables were measured.

# 9.3.1 Special Corrections/Adjustments

None.

#### 9.3.2 Calculated Variables

None.

#### 9.4 Graphs and Plots

None.

#### 10. Errors

#### 10.1 Sources of Error

Analyses of all components were conducted on a uniform basis but there are some missing values that have been accounted for in averages and standard error calculations.

#### 10.2 Quality Assessment

None.

#### 10.2.1 Data Validation by Source

Data were checked for obvious problems.

# 10.2.2 Confidence Level/Accuracy Judgment

High.

#### **10.2.3 Measurement Error for Parameters**

None.

#### 10.2.4 Additional Quality Assessments

None.

#### 10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

#### 11. Notes

#### 11.1 Limitations of the Data

None.

#### 11.2 Known Problems with the Data

None.

#### 11.3 Usage Guidance

This data file does not contain values for subsamples. A sample represents a tree and comprises two subsamples. The averaged content in TABLE2 is that of five samples (replications). Standard errors are among samples, not between subsamples.

#### 11.4 Other Relevant Information

None.

# 12. Application of the Data Set

These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing.

#### 13. Future Modifications and Plans

None given.

#### 14. Software

#### 14.1 Software Description

None given.

#### 14.2 Software Access

None given.

#### 15. Data Access

The NSA canopy biochemistry data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

#### **15.1 Contact Information**

For BOREAS data and documentation please contact:

ORNL DAAC User Services Oak Ridge National Laboratory P.O. Box 2008 MS-6407 Oak Ridge, TN 37831-6407 Phone: (423) 241-3952

Phone: (423) 241-3952 Fax: (423) 574-4665

E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

#### 15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

#### 15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

#### 15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

# 16. Output Products and Availability

# 16.1 Tape Products

None.

#### 16.2 Film Products

None.

#### 16.3 Other Products

These data are available on the BOREAS CD-ROM series.

#### 17. References

# **17.1 Platform/Sensor/Instrument/Data Processing Documentation** None given

17.2 Journal Articles and Study Reports

Anonymous. 1993. UV-method for the determination of native starch in foodstuffs and other materials. Boehringer Mannheim. Cat. No. 207748. Test combination for ca. 25 determinations.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers, and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350-356.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Parkinson, J.A. and S.E. Allen. 1975. A wet oxidation procedures suitable for the determination of nitrogen and mineral nutrients in biological material. Comm. Soil Sci. Plant Anal 6: 1-11.

Ryan, M.G., J.M. Melillo, and A. Ricca. 1990. A comparison of methods for determining proximate carbon fractions of forest litter. Can. J. For. Res. 20: 166-171. Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

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Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

# 17.3 Archive/DBMS Usage Documentation None.

# 18. Glossary of Terms

None given.

# 19. List of Acronyms

ASCII - American Standard Code for Information Interchange AVIRIS - Airborne Visible-Infrared Imaging Spectrometer

BOREAS - BOReal Ecosystem-Atmosphere Study

BORIS - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory

CGI - Certified by Group

CPI - Checked by Principal InvestigatorDAAC - Distributed Active Archive Center

EOS - Earth Observing System

EOSDIS - EOS Data and Information System
FFC-T - Focused Field Campaign-Thaw
FFC-W - Focused Field Campaign-Winter
GIS - Geographic Information System
GSFC - Goddard Space Flight Center
HTML - Hyper-Text Markup Language
IFC - Intensive Field Campaign
NAD83 - North American Datum of 1983

NASA - National Aeronautics and Space Administration

NSA - Northern Study Area

OA - Old Aspen

OBS - Old Black Spruce OJP - Old Jack Pine

ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park

PRE - Preliminary

SSA - Southern Study Area

TE - Terrestrial Ecology

UBS - Upland Black Spruce

URL - Uniform Resource Locator

UTM - Universal Transverse Mercator

YJP - Young Jack Pine

#### 20. Document Information

#### **20.1 Document Revision Date**

Written: 01-Jan-1997 Last Updated: 20-Apr-1999

#### 20.2 Document Review Date(s)

BORIS Review: 08-Sep-1997 Science Review: 05-Nov-1997

#### 20.3 Document ID

#### 20.4 Citation

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

Samples were collected by Hank Margolis and other TE-09 members. Results are from laboratory analyses conducted by Martin Charest. Data compilation was conducted by Mikailou Sy.

### If using data from the BOREAS CD-ROM series, also reference the data as:

H. Margolis, "Relationship Between Measures of Absorbed and Reflected Radiation and the Photosynthetic Capacity of Boreal Forest Canopies and Understories." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

#### Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

#### 20.5 Document Curator

#### 20.6 Document URL

### REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE October 2000	_	B. REPORT TYPE AND DATES COVERED Technical Memorandum			
4. TITLE AND SUBTITLE  Technical Report Series on the Bo BOREAS TE-9 NSA Canopy	oreal Ecosystem-Atmosphere		5. FUNDING NUMBERS  923			
6. AUTHOR(S)  Hank Margolis, Martin Chare Forrest G. Hall and Shelaine	RTOP: 923-462-33-01					
7. PERFORMING ORGANIZATION NAME Goddard Space Flight Center Greenbelt, Maryland 20771	E(S) AND ADDRESS (ES)		8. PEFORMING ORGANIZATION REPORT NUMBER  2000-03136-0			
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)  National Aeronautics and Space Administration Washington, DC 20546-0001			10. SPONSORING / MONITORING AGENCY REPORT NUMBER TM—2000–209891 Vol. 154			
11. SUPPLEMENTARY NOTES  H. Margolis, M. Charest, and S. Curd: Raytheon ITSS, NA	•	• • •				
12a. DISTRIBUTION / AVAILABILITY STA Unclassified—Unlimited Subject Category: 43 Report available from the NASA 7121 Standard Drive, Hanover,	A Center for AeroSpace Inf	•	12b. DISTRIBUTION CODE			

#### 13. ABSTRACT (Maximum 200 words)

The BOREAS TE-9 team collected several data sets related to chemical and photosynthetic properties of leaves. This data set contains canopy biochemistry data collected in 1994 in the NSA at the YJP, OJP, OBS, UBS, and OA sites, including biochemistry lignin, nitrogen, cellulose, starch, and fiber concentrations. These data were collected to study the spatial and temporal changes in the canopy biochemistry of boreal forest cover types and how a high-resolution radiative transfer model in the mid-infrared could be applied in an effort to obtain better estimates of canopy biochemical properties using remote sensing. The data are available in tabular ASCII files.

14. SUBJECT TERMS BOREAS, terrestrial eco	15. NUMBER OF PAGES 20 16. PRICE CODE		
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT $UL$